Υ and J/ψ Photoproduction in pp and $\overline{p}p$ Collisions

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Photoproduction has traditionally been studied with fixed target photon beams, at electron-proton colliders, and, to a limited extent, at relativistic heavy ion colliders. However, energetic protons also have large electromagnetic fields, and high energy pp and $\overline{p}p$ colliders can be used to study photoproduction, at photon energies higher than are currently accessible. Photoproduction offers a way to measure the gluon distribution in protons at low Feynman$-x$ [1].

Here, we consider one example, photoproduction of heavy quark vector mesons in $\overline{p}p$ collisions at the Fermilab Tevatron and in pp collisions at Brookhaven's RHIC and at the CERN Large Hadron Collider (LHC). At the Tevatron, the high rates allow for measurements of gluon distributions around $x \approx 1.5-5\times10^{-3}$, and at the LHC $x \approx 2-7\times10^{-4}$ can be reached.

The production cross section is

$$\sigma = 2\int \frac{dn_\gamma}{dk}\sigma_{\gamma p}(k). \qquad (1)$$

The '2' accounts for the fact that either proton can emit the photon. The photon flux is given by the Weizsä cker-Williams method. However, because protons have internal structure, it is necessary to include a form factor. We use the dipole form factor method of Drees and Zeppenfeld. The photon-proton cross section is based on HERA data. Fig. 1 shows $d\sigma/dy$ for the Υ at RHIC and the Tevatron [2].

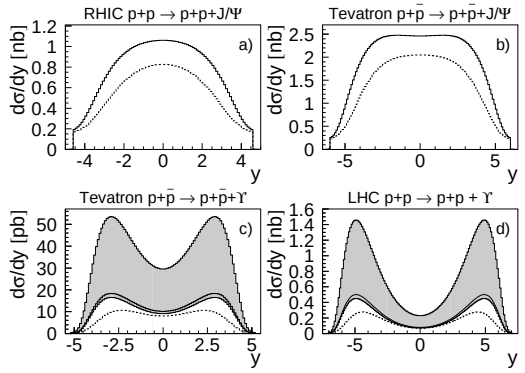

FIG. 1: $d\sigma/dy$ for the Υ at the Tevatron ($\sqrt{s} = 1.96$ TeV $p\overline{p}$) and the J/ψ at RHIC ($\sqrt{s} = 500$ GeV pp collisions).

As with ion collisions, the two possibilities: proton 1 emitting a photon which strikes proton 2, and vice-versa, intefere. This interference alters the transverse momentum, p_T spectrum, but not the total cross section. The p_T spectrum at midrapidity is given by

$$\sigma \approx |A_1|^2\left(1 \pm \cos(\vec{p}_T \cdot \vec{b})\right) . \qquad (2)$$

where A_1 is the amplitude for photoproduction from a selected proton. The sign of the cosine term depends on the symmetry of the system. In pp or AA collisions, moving the meson production from one ion to the other is equivalent to a parity transform. Vector mesons are negative parity, so the sign is negative. However, at a $\overline{p}p$ collider, the move corresponds to CP symmetry. Vector mesons are CP positive, so the amplitudes add. Figure 2 shows the p_T spectra for the Υ at RHIC and the Tevatron; because of the different symmetries, the spectra are very different.

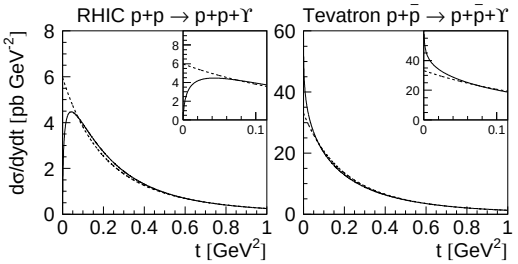

FIG. 2: $d\sigma/dt$ for Υ at RHIC and the Tevatron. Because of the different sign of the interference, the spectra are very different.

REFERENCES

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